ENGINEERING CHANGE NOTICE

1. ECN 635507

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental [] Direct Revision [X] Change ECN [] Temporary [] Standby [] Supersedure [] Cancel/Void []	Cheryl J. Benar, Data Assessment and Interpretation, R2-12, 372-1256	[] Yes [X] No	07/25/97
	6. Project Title/No./Work Order No.: Tank 241-B-109	7. Bldg./Sys./Fac. No.: 241-B-109	8. Approval Designator: N/A
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.): HNF-SD-WM-ER-677, Rev. 0	10. Related ECN No(s).: N/A	11. Related PO No.: N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change 13b. Design Baseline Document? [] Yes [X] No

This ECN was generated to include additional explanatory text in the best-basis narrative, and to update the comprehensive radionuclide inventory estimates for the tank.

Rev. 0 pages included for duplicating purposes only.

14a. Justification (mark one)

Criteria Change	[]	Design Improvement	[X]	Environmental	[]	Facility Deactivation	[]
As-Found	[]	Facilitate Const	[]	Const. Error/Omission	[]	Design Error/Omission	[]

14b. Justification Details

Initial release of this document was deficient.

15. Distribution (include name, MSIN, and no. of copies)

See attached distribution.

RELEASE STAMP

DATE: AUG 27 1997 STA: 4 HANFORD RELEASE ID: 2

ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1): ECN-635507

16. Design Verification Required	17. Cost Impact				18. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[] Yes	Additional	[] $	Additional	[] $	Improvement	[]
[X] No	Savings	[] $	Savings	[] $	Delay	[]

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

SDD/DD	[]	Seismic/Stress Analysis	[]	Tank Calibration Manual	[]
Functional Design Criteria	[]	Stress/Design Report	[]	Health Physics Procedure	[]
Operating Specification	[]	Interface Control Drawing	[]	Spares Multiple Unit Listing	[]
Criticality Specification	[]	Calibration Procedure	[]	Test Procedures/Specification	[]
Conceptual Design Report	[]	Installation Procedure	[]	Component Index	[]
Equipment Spec.	[]	Maintenance Procedure	[]	ASME Coded Item	[]
Const. Spec.	[]	Engineering Procedure	[]	Human Factor Consideration	[]
Procurement Spec.	[]	Operating Instruction	[]	Computer Software	[]
Vendor Information	[]	Operating Procedure	[]	Electric Circuit Schedule	[]
OM Manual	[]	Operational Safety Requirement	[]	ICRS Procedure	[]
FSAR/SAR	[]	IEFD Drawing	[]	Process Control Manual/Plan	[]
Safety Equipment List	[]	Cell Arrangement Drawing	[]	Process Flow Chart	[]
Radiation Work Permit	[]	Essential Material Specification	[]	Purchase Requisition	[]
Environmental Impact Statement	[]	Fac. Proc. Samp. Schedule	[]	Tickler File	[]
Environmental Report	[]	Inspection Plan	[]		[]
Environmental Permit	[]	Inventory Adjustment Request	[]		[]

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
N/A		

21. Approvals

	Signature	Date		Signature	Date
Design Authority			Design Agent		
Cog. Eng. C.J. Benar	C.J. Benar	8/27/97	PE		
Cog. Mgr. K.M. Hall	Kathleen M. Hall	8/27/97	QA		
QA			Safety		
Safety			Design		
Environ.			Environ.		
Other			Other		

DEPARTMENT OF ENERGY

Signature or a Control Number that tracks the Approval Signature

ADDITIONAL

Tank Characterization Report for Single-Shell Tank 241-B-109

Cheryl J. Benar
Lockheed Martin Hanford, Corp., Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

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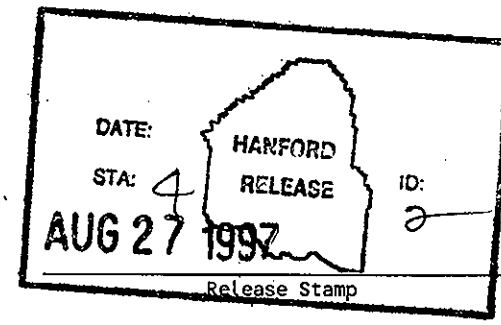
Key Words: Waste Characterization, Single-Shell Tank, SST, Tank 241-B-109, 241-B-109, B-109, B Farm, Tank Characterization Report, TCR, Waste Inventory, TPA Milestone M-44

Abstract: This document summarizes the information on the historical uses, present status, and the sampling and analysis results of waste stored in Tank 241-B-109. This report supports the requirements of the Tri-Party Agreement Milestone M-44-10.

Release Approval 8/27/97 Date



Approved for Public Release

RECORD OF REVISION	(1) Document Number HNF-SD-WM-ER-677	Page 1

(2) Title
Tank Characterization Report for Single-Shell Tank 241-B-109

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
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0	(7) Initially released 05/30/97 on EDT-617567.	C.J. Benar	K.M. Hall
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		C.J. Benar 8/27/97	Kathleen M. Hall 8/27/97

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LIST OF TERMS

1C	first-cycle decontamination waste
ANOVA	analysis of variance
Btu/hr	British thermal units per hour
BSltCk	saltcake waste
Ci	curie
Ci/L	curies per liter
cm	centimeter
CW	aluminum cladding waste
CWP	PUREX cladding waste
CWP2	PUREX process aluminum cladding waste
DQO	data quality objective
DSC	differential scanning calorimetry
EB	evaporator bottoms (slurry product from evaporators)
ft	feet
g	gram
g/cm^3	grams per cubic centimeter
g/gal	grams per gallon
g/L	grams per liter
g/mL	grams per milliliter
$g/\mu g$	grams per microgram
HDW	Hanford defined waste
HTCE	historical tank content estimate
IC	ion chromatography
ICP	inductively coupled plasma spectroscopy
in.	inch
J/g	joules per gram
kg	kilogram
kgal	kilogallon
kg/L	kilograms per liter
kL	kiloliter
L/kL	liters per kiloliter
LFL	lower flammability limit
LL	lower limit
m	meter
mm	millimeter
M	moles per liter
mrad/hr	millirads per hour
n/a	not applicable
n/r	not reported
PHMC	Project Hanford Management Contractor
ppm	parts per million

Table 3-1. Best-Basis Inventory Estimate for Nonradioactive Components in Tank 241-B-109 (Effective January 31, 1997). (2 Sheets)

Analyte	Total Inventory (kg)	Basis (S, M, or E)[1]	Comment
Si	2,880	S	IC basis
S as SO_4	84,300	S	
Sr	0	M	Poor sample basis
TOC	1,080	S	
U_{TOTAL}	13,800	S	Near detection limit
Zr	4.9	M	No sample basis

Notes:

C = calculated by charge balance
IC = ion chromatography
ICP = inductively coupled plasma
TIC = total inorganic carbon
TOC = total organic carbon

[1]S = sample-based, M = HDW model-based, and E = engineering assessment-based.

Table 3-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-B-109, Decayed to January 1, 1994 (Effective January 31, 1997). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	23.6	M	
^{14}C	3.88	M	
^{59}Ni	0.265	M	
^{60}Co	5.52	M	
^{63}Ni	24.5	M	
^{79}Se	0.302	M	
^{90}Sr	8.53E+03	M	Poor sample basis
^{90}Y	8.53E+03	M	Based on ^{90}Sr
^{93}Zr	1.50	M	
^{93m}Nb	1.08	M	
^{99}Tc	33.8	M	
^{106}Ru	6.76E-04	M	
^{113m}Cd	8.41	M	
^{125}Sb	24.6	M	
^{126}Sn	0.453	M	
^{129}I	6.53E-02	M	
^{134}Cs	0.171	M	
^{137}Cs	17,000	E	Based on tank 241-B-108
^{137m}Ba	16,000	E	Based on ^{137}Cs
^{151}Sm	1.07E+03	M	
^{152}Eu	0.287	M	
^{154}Eu	67.4	M	
^{155}Eu	18.1	M	
^{226}Ra	1.83E-05	M	
^{227}Ac	9.01E-02	M	
^{228}Ra	9.01E-02	M	
^{229}Th	3.22E-03	M	
^{231}Pa	1.24E-02	M	
^{232}Th	1.09E-02	M	

Table 3-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-B-109, Decayed to January 1, 1994 (Effective January 31, 1997). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{232}U	0.324	M	
^{233}U	1.25	M	
^{234}U	2.40	M	
^{235}U	0.104	M	
^{236}U	3.84E-02	M	
^{238}U	2.44	M	
^{237}Np	0.117	M	
^{238}Pu	3.18	M	
^{239}Pu	144	M	Poor sample basis
^{240}Pu	24.1	M	
^{241}Pu	251	M	
^{242}Pu	7.16E-04	M	
^{241}Am	4.32	M	
^{243}Am	1.41E-04	M	
^{242}Cm	9.37E-04	M	
^{243}Cm	2.25E-05	M	
^{244}Cm	9.22E-05	M	

Note:

[1]S = Sample-based, M = Hanford Defined Waste model-based, E = Engineering assessment-based.

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APPENDIX D

EVALUATION TO ESTABLISH BEST-BASIS INVENTORY FOR TANK 241-B-109

An effort is underway to provide waste inventory estimates that will serve as standard characterization source terms for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of available information for tank 241-B-109 was performed, and a best-basis inventory was established. This work, detailed in the following sections, follows the methodology that was established by the standard inventory task.

D1.0 CHEMICAL INFORMATION SOURCES

Characterization results from the most recent sampling event for this tank are provided in Appendix B. Two core samples (cores 169 and 170) were obtained in 1996 from two different risers. The component concentrations are based on segment means from which a core mean and overall tank mean were derived. The analytical data from core samples from tanks 241-B-104, 241-B-106, and 241-B-108, which process records indicate contain the same saltcake waste type as tank 241-B-109, provided useful comparison information. The HDW model (Agnew et al. 1997a) also provides tank content estimates in terms of component concentrations and inventories.

D2.0 COMPARISON OF COMPONENT INVENTORY VALUES

Sample-based inventories derived from the analytical concentration data and HDW model inventories (Agnew et al. 1997a), are compared in Table D2-1. The tank volume used to generate these inventories is 481 kL (127 kgal). This volume, which is reported in Hanlon (1997), is the same as that reported by Agnew et al. (1997a). The density used to calculate the component inventories is 1.87 g/mL based on sample measurements, which is higher than the value reported in Agnew et al. (1997a). The HDW model estimates the density to be 1.61 g/mL. This difference in density provides an RPD of 15 percent for analytes with roughly the same concentrations. Note that the sample-based and HDW model inventories differ significantly for several components; e.g., Al, Cl, F, NO_3, PO_4, and SO_4. The chemical species are reported without charge designation according to the best-basis inventory convention.

A list of references used in this evaluation is provided in Section D5.0.

Table D2-1. Sample-Based and Hanford Defined Waste-Based Inventory Estimates for Nonradioactive Components in Tank 241-B-109.

Analyte	Sampling Inventory Estimate[1] (kg)	HDW Model Inventory Estimate[2] (kg)	Analyte	Sampling Inventory Estimate[1] (kg)	HDW Model Inventory Estimate[2] (kg)
Al	52,700	13,700	NO_2	5,700	17,200
Bi	<4,200	1,230	NO_3	92,600	196,000
Ca	<1,590	1,590	P as PO_4	89,000	31,000
Cl^-	648	1,770	Pb	<1,560	3,370
Cr	1,930	589	Si	5,330	494
F^-	21,500	801	S as SO_4	69,300	7,230
Fe	5,290	3,360	Sr	<150	0
Hg	n/r	59.9	TIC as CO_3	7,850	7,510
K	n/r	459	TOC	1,450	1,250
La	<755	0.049	U_{TOTAL}	<11,000	7,100
Mn	<386	30.7	Zr	<150	4.9
Na	178,000	123,000	H_2O (wt%)	37.7	41.7
Ni	n/r	174			

Notes:

n/r = not reported

[1]Appendix B, Section B3.4.3
[2]Agnew et al. (1997a)

D3.0 COMPONENT INVENTORY EVALUATION

The following evaluation of tank contents is performed to identify potential errors and/or missing information that would influence the sample-based and HDW model component inventories.

D3.1 CONTRIBUTING WASTE TYPES

Tank 241-B-109 is the last tank in a cascade that includes tank 241-B-107 and 241-B-108. In 1946, tank 241-B-109 began receiving 1C waste cascaded from tank 241-B-108 (Agnew et al. 1997b). Tank 241-B-109 was filled by the second quarter of 1946.

Significant amounts of 1C solids are not expected to have cascaded to tank 241-B-109. The tank was nearly emptied in 1952 when the waste was transferred to the 242-B feed tank (tank 241-B-106). In 1952, tank 241-B-109 began receiving salt liquors from tank 241-B-106, which was the 242-B evaporator feed tank. In 1954, re-evaporated 1C bottoms were received from tank 241-B-105, which was the active bottoms tank. From 1963 until approximately 1965, PUREX process aluminum cladding waste was transferred to tank 241-B-109 (Agnew et al. 1997b).

Based on this process history, the majority of the solids expected in tank 241-B-109 included saltcake solids (evaporator bottoms [EB],or BSltCk) from the 242-B Evaporator, and aluminum cladding waste from PUREX process operation. Additional detail relevant to the waste transfer history is provided in Appendix A of this report.

D3.1.1 Predicted Current Waste Types and Volumes

Information concerning the waste types presently contained in tank 241-B-109 is inconsistent. The HDW model (Agnew et al. 1997a) predicts the following waste types.

Waste Type	Waste Volume - kL (kgal)
BSltCk	318 (84)
CWP2	49 (13)
Unknown waste origin (UNK)	113 (30)
Total	480 (127)

However, Agnew et al. (1997a) assumes that the chemical composition of the UNK waste is the same as BSltCk. The HDW model prediction for waste volumes is thus equivalent to the following:

Waste Type	Waste Volume - kL (kgal)
BSltCk	431 (114)
CWP2	49 (13)
Total	480 (127)

D3.1.2 Evaluation of Segment-Level Data

The sort on radioactive waste type model (Hill et al. 1995) lists 1C, EB, and aluminum cladding waste (CW) as the primary, secondary, and tertiary waste types, respectively. Hill et al. (1995) and Hanlon (1997) both report the total waste volume as 481 kL (127 kgal), which is consistent with Agnew et al. (1997a). Both Hill and Hanlon, however, report that the waste consists entirely of sludge, whereas Agnew et al. (1997a) credits at least 318 kL (84 kgal) to saltcake.

Evaluation of segment-level core sample data indicates considerable vertical and horizontal nonuniformity for concentrations of most major analytes. The analyte concentrations differ vastly between the two core samples (see Appendix B, Section B3.0). Core 169 contains significant concentrations of Al (approximately 7.0*M*) which is likely indicative of aluminum cladding waste as predicted by Agnew et al. (1997a). The concentration of PO_4 in core 169 ranges from 1 to 4*M*, which indicates mixing of up to 50 volume percent 242-B Evaporator saltcake with the cladding waste.

Segment-level analyses for core sample 170 indicate unexpectedly high concentrations of SO_4 and F (approximately 4.0*M* in segment 2), whereas SO_4 and F concentrations in core 169 are only approximately 0.03 and 0.6, respectively. The PO_4 concentration in core 170 is similar to that for core 169 (1 to 4*M*). The chemical composition of core 170 reflects components that would be expected from evaporation of $BiPO_4$ process 1C waste (Schneider 1951), although with unexpectedly high concentrations for the noted anions.

Evaluation of segment-level data for cores 169 and 170 shows no indication of the 1C sludge layer predicted by Hill et al. (1995). The core samples from tank 241-B-109 thus indicate the presence of both cladding waste (core 169) and 242-B Evaporator saltcake (core 170).

As previously noted, Agnew et al. (1997a) assumes that the composition of the 113 kL (30 kgal) UNK waste in tank 241-B-109 is the same as BSltCk, which proportions the total waste volume as 49 kL (13 kgal) CWP2 and 431 kL (114 kgal) BSltCk. However, the high concentration of Al in both segments of core 169 could indicate significantly more than 49 kL (13 kgal) CWP2. This engineering evaluation assumes that cores 169 and 170 each

represent half of the waste volume in the tank. Because core 169 is estimated to consist of approximately 50 volume percent CW and 50 volume percent BSltCk, and core 170 consists of essentially 100 percent BSltCk, the following approximate volumes for these waste types are assumed in this evaluation:

Waste Type	Waste Volume - kL (kgal)
242-B Evaporator saltcake	360 (95)
Cladding waste	120 (32)
Total	480 (127)

D3.2 BASIS FOR ASSESSING SALTCAKE INVENTORIES IN 241-B-109

BSltCk, the abbreviation used by Agnew et al. (1997a) is representative of salt waste supernatants that were evaporated and concentrated in the 242-B Evaporator until they were largely solidified. Agnew et al. (1997a) provides a single average composition for the BSltCk defined waste. However, historical records (Anderson 1990, Agnew et al. 1997a) indicate that supernatants from the first cycle bismuth phosphate process (1C waste), as well as supernatants from the uranium recovery (UR) process were evaporated in the 242-B Evaporator and transferred to several tanks in the 241-B Tank Farm. The chemical compositions of the dilute supernatants from these processes differed. Because the supernatants were not all blended together before evaporation, the saltcake compositions resulting from evaporation of these wastes are also expected to differ, both as a function of position within a tank, and as a function of which tank was used as a receiver at a particular time.

Because of the complicated waste supernatant transfer history of feed to the 242-B Evaporator and the lack of a flowsheet basis for the waste, it is difficult to perform an independent assessment to estimate the saltcake composition that can be compared to the model-based BSltCk composition. However, waste samples from a limited number of B Tank Farm tanks expected to contain BSltCk have been analyzed and reported. The composition data for tanks 241-B-104 (Field 1996), 241-B-106 (McCain 1996) and 241-B-108 (Schreiber 1997), are summarized in Table D3-1. The analytical results for these tanks were evaluated at the core segment level to identify the areas representing BSltCk. For comparison, data for core 170 from tank 241-B-109 are shown. The core 169 data are not shown because this core is assumed to contain primarily cladding waste. The analytical results for tank 241-B-109 were averaged based on the weight of a full-core segment. The full-core segment weight was derived by correcting for the reported segment volume percent recovery.

To provide a common basis for comparison of the data in Table D3-1, the reported water mass was removed from the results; that is, the results are all compared on a water-free basis. The HDW model composition for BSltCk (also on a water-free basis) is included in Table D3-1 for comparison.

Table D3-1. Composition of 242-B Evaporator Saltcake (Water-Free Basis). (2 sheets)

Analyte	241-B-104	241-B-106	241-B-108	241-B-109	HDW Model[3] BSltCk
	μg/g	μg/g	μg/g[1]	μg/g[2]	μg/g
Al	3,471	6,925	40,400	40,380	432
Bi	21,516	7,238	<3,130	6,808	3,818
Ca	618	4,499	<3,020	<2,950	2,894
Cr	966	666	355	1,420	290
Fe	19,857	35,011	<1,570	5,908	6,666
K	n/r	315	1,900	n/r	599
La	n/r	<73	<1,570	<1,475	0
Mn	n/r	403	<302	<295	0
Na	220,620	228,337	343,560	417,902	295,250
Ni	n/r	129	n/r	n/r	500
Pb	n/r	741	<3,020	<3,023	0
Si	10,729	4,092	2,051	2,236	1,170
Sr	n/r	911	<302	<295	0
U	3,616	27,821	1,930	<14,750	n/r
Zr	n/r	<73	<302	<295	139
CO_3	n/r	1,625	6,925	n/r	11,480
Cl	3,974	3,334	1,471	1,495	3,030
F	6,516	5,632	61,280	79,614	1,979
NO_3	546,139	409,639	114,590	219,962	547,100
NO_2	4,614	16,044	19,275	7,907	11,150
PO_4	43,879	66,436	182,070	125,628	95,690
SO_4	41,153	31,312	183,700	316,880	12,770

Table D3-1. Composition of 242-B Evaporator Saltcake (Water-Free Basis). (2 sheets)

	241-B-104	241-B-106	241-B-108	241-B-109	HDW Model[3] BSltCK
Radionuclide	μCi/g	μCi/g	μCi/g	μCi/g	μCi/g
^{137}Cs	n/r	50.5	23.5	n/r	29.3
^{90}Sr	n/r	149	3.3	n/r	7.5
$^{239/240}Pu$	n/r	n/r	n/r	n/r	0.029

Notes:

[1]Data from upper half segment 1 from cores 172 and 173 are not included because these partial segments contained primarily CW.

[2]Core 170. Core 169 data are not shown because this core contained primarily CW.

[3]Agnew et al. (1997b)

As shown in Table D3-1, the concentrations of most components in tank 241-B-104 (with the exception of Bi and PO_4) agree quite well with those for tank 241-B-106. Similarly, the concentration of components in tank 241-B-108 agree quite well with those for tank 241-B-109 (core 170). However, the component concentrations in tanks 241-B-104 and 241-B-106 differ markedly from those in tank 241-B-108 and 241-B-109.

Transfer records (Agnew et al. 1997b) indicate that tank 241-B-109 was the last tank to receive evaporator bottoms from tank 241-B-105. Tank 241-B-105 was the active bottoms tank at that time. The records indicate that both evaporated 1C waste and probably evaporated UR waste was transferred from tank 241-B-105 to 241-B-109. The high concentrations of F, SO_4, and PO_4 in tank 241-B-109 may reflect precipitation of those components from highly concentrated residual liquors that resulted from the final pass through the 242-B Evaporator.

The analyte concentrations for core 170 from tank 241-B-109 are considered an appropriate basis for estimating the inventory of chemical components for the fraction of BSltCk waste in this tank. The component concentrations are not consistent with two other tanks (241-B-104 and 241-B-106) believed to contain BSltCk. However, they are consistent with those for tank 241-B-108, which (like tank 241-B-109) also received highly concentrated salt liquors from 242-B Evaporator operations. This difference suggests a phasing and distribution issue. Perhaps earlier evaporator concentrates derived from 1C waste were placed in tanks 241-B-108 and 241-B-109, and later concentrates derived from UR waste were placed in tanks 241-B-104 and 241-B-106.

The inventory for BSltCk components was calculated as the product of the core 170, tank 241-B-109 component concentrations in Table D3-1 (corrected to include 41.7 weight percent H_2O), a waste volume of 240 kL (63.5 kgal) and the core 170 sample measured density of 1.885 g/mL (see Appendix B). As previously noted, core 170 is assumed to account for half of the tank chemical inventory. The inventory for the remaining BSltCk (and CWP) estimated to be in the tank is accounted for from core 169 (see Section D3.3).

An example calculation for the Al content in the BSltCk in tank 241-B-109 is shown below:

$$40{,}380\ \mu g/g \times (1-.417) \times 1.0E\text{-}06\ g/\mu g \times 1.885\ kg/L \times 240\ kL \times 1{,}000\ L/kL = 10{,}650\ kg\ Al$$

D3.3 BASIS FOR ASSESSING CLADDING WASTE INVENTORY IN TANK 241-B-109

Matheison and Nicholson (1968) provide the PUREX process flowsheet basis for the neutralized aluminum cladding waste. The major components include Na, Al, Si, NO_2, and NO_3. Table D3-2 shows the analyte concentrations (on a water-free basis) for core 169 from tank 241-B-109. Also shown for comparison is the defined waste composition for CWP2 from the HDW model. The high Al and Si concentrations in the sample indicate that the sample data are consistent with the flowsheet basis for cladding waste. The presence of significant amounts of uranium suggests that some fuel core material also is present. The high concentration of Al in this sample is comparable to that for the HDW-model-defined waste. However, the core 169 sample also contains an estimated 50 volume percent BSltCk, which increases component concentrations in particular for Na, NO_3, PO_4, and F. The HDW model CWP2 defined waste does not indicate Si, whereas significant concentrations of Si were found in the core sample. The presence of Si in aluminum cladding waste is expected because the decladding process attacks the Al-Si alloy bonding. It is not clear why the HDW model does not indicate Si for the defined waste.

The analytical data for core 169 are considered an appropriate basis for estimating the inventory of components for the cladding waste/BSltCk mixture in tank 241-B-109. This core sample is assumed to represent 240 kL (63 kgal) of waste, which accounts for the approximately 120 kL (32 kgal) of cladding waste estimated to be in the tank, and for 120 kL of the total of 360 kL (95 kgal) of 242-B evaporator saltcake estimated to be in the tank (Section D3.1).

The inventory for the cladding waste/saltcake mixture was calculated as the product of the component concentrations from Table D3-2 (corrected to include 44.9 weight percent H_2O), a waste volume of 240 kL (63 kgal), and the core 169 sample measured density of 1.85 g/mL (Appendix B).

An example calculation for the Al content in the cladding waste in tank 241-B-109 follows:

189,264 μg/g x (1-.449) x 1.0E-06 g/μg x 1.85 kg/L x
240 kL x 1,000 L/kL = 46,300 kg Al.

Table D3-2. Chemical Compositions of Cladding Wastes (Water-Free Basis). (2 sheets)

Analyte	241-B-109[1] (μg/g)	HDW Model CWP2[2] (μg/g)
Al	189,264	213,700
Bi	<3,720	0
Ca	<3,650	17,410
Cr	5,692	164
Fe	8,962	13,990
K	n/r	101
La	<1,664	0
Mn	1,069	0
Na	281,149	38,430
Ni	n/r	93
Pb	<3,320	91,250
Si	9,378	0
Sr	<331	0
U	42,586	n/r
Zr	<331	0
CO_3	n/r	0
Cl	1,463	422
F	11,762	0
Anions	**μg/g**	**μg/g**
NO_3	101,069	43,320
NO_2	20,668	13,950
PO_4	163,691	0
SO_4	3,115	1,249

Notes:
[1]Core 169
[2]Agnew et al. (1997a)

D3.4 COMPARISON OF INVENTORY ESTIMATES

Estimated inventories from this evaluation for selected components are compared with the HDW model-based inventories in Table D3-3. Estimated inventories for the saltcake component (Section D3.2) and cladding waste component (Section D3.3) were added together to provide the total tank inventory estimate. It should be noted that although the inventory estimate in Table D3-3 is based primarily on the tank 241-B-109 core sample analyses, it differs from the sample-based inventory shown in Table D2-1 and Appendix B (Section B3.4). This is because the component concentrations for the two core samples were calculated for this assessment by correcting for the reported waste recoveries. The mean concentrations in Appendix B were derived using ANOVA techniques.

Comments and observations regarding these inventories are provided by component in the following text.

Table D3-3. Estimated Chemical Inventory for Tank 241-B-109.

Analyte	241-B-109 Sample-Based (kg)	HDW Model Inventory (kg)
Al	57,000	13,700
Bi	<2,860	1,230
Cr	1,770	589
Fe	3,740	3,360
Si	2,880	494
Na	179,000	123,000
U	<13,800	7,100
F	23,900	801
NO_3	82,800	196,000
NO_2	7,130	17,200
PO_4	73,200	31,000
SO_4	84,300	7,230

Aluminum. The sample-based aluminum inventory estimate is over four times that predicted by the HDW model. This assessment assumes a larger contribution of cladding waste in this tank, which increases the Al content by approximately 50 percent over that predicted by the model. In addition, however, the Al concentration in tank 241-B-109 saltcake (and also tank 241-B-108 saltcake) is approximately 100-fold higher than predicted by the HDW model. The HDW model assumes a low solubility for Al in salt supernatants before evaporation to saltcake. This assumption appears to be incorrect.

Bismuth. The total Bi inventory for both estimates is low, which indicates that essentially no $BiPO_4$ process 1C sludge is present in tank 241-B-109. The small amount of Bi is likely present as soluble species in the BSltCk, and is from very minor amounts of 1C sludge.

Iron and Chromium. The sample-based Cr inventory is three-fold higher than predicted by the HDW model. The sample-based and model-based Fe inventories are comparable. The HDW model predicts Fe concentrations in cladding waste and 242-B saltcake close to those observed for the tank 241-B-109 core samples. However, consistently higher Cr concentrations were found in the 241-B-109 saltcake (as well as the other 241-B Tank Farm saltcake comparison tanks) than predicted by the HDW model.

Silicon. The Si inventory estimated by this assessment is six-fold higher than the HDW model inventory. The largest contribution of Si is from the cladding waste (observed for core 169). The presence of Si in aluminum cladding waste is expected because the decladding process attacks the Al-Si alloy bonding. The HDW model apparently does not account for dissolution of Si as part of the decladding mechanism, suggesting a missing or incomplete source term.

Sodium. The Na inventory estimate is approximately 50 percent higher than predicted by the HDW model. The 242-B Evaporator saltcake in both tanks 241-B-108 and 241-B-109 exhibits significantly higher Na concentrations than were found in the other 242-B Evaporator saltcake tanks. This assessment concludes that the higher concentrations for Na (as well as F and SO_4) are characteristic of some saltcakes resulting from the final pass of highly concentrated supernatants through the 242-B Evaporator.

Fluoride and Sulfate. The F and SO_4 inventories estimated by this evaluation are 30 times and 12 times higher, respectively, than predicted by the HDW model. The F and SO_4 concentrations in both 241-B-108 and 241-B-109 tank samples were significantly higher than found in the other 242-B saltcake comparison tank samples. Furthermore, none of the analytes that correlate with elevated concentrations (Si, Zn, or La) were observed. It is concluded that the tank 241-B-109 samples are characteristic of saltcake resulting from the final pass of highly concentrated supernatants through the 242-B Evaporator.

Nitrate. The NO_3 inventory estimate is about half of that predicted by the HDW model. As evidenced by the saltcake samples from tanks 241-B-108 and 241-B-109, it is thought that less soluble components, e.g., F and SO_4, precipitated preferentially from highly concentrated residual liquors during the final pass through the 242-B Evaporator.

Hydroxide. Once the best-basis inventories were determined, the hydroxide inventory was calculated by performing a charge balance with the other ionic species. In some cases, this approach requires that other cation or anion (e.g., sodium or nitrate) inventories be adjusted to achieve the charge balance. During such adjustments, significant figures are retained. This charge balance approach is consistent with that used by Agnew et al. (1997a).

D4.0 DEFINE THE BEST-BASIS AND ESTABLISH COMPONENT INVENTORIES

Information about chemical, radiological, and/or physical properties is used to perform safety analyses, engineering evaluations, and risk assessments associated with waste management activities, as well as to address regulatory issues. These activities include overseeing tank farm operations and identifying, monitoring, and resolving safety issues associated with these operations and with the tank wastes. Disposal activities involve designing equipment, processes, and facilities for retrieving wastes and processing them into a form that is suitable for long-term storage.

Chemical and radiological inventory information is generally derived using three approaches: 1) component inventories are estimated using results of sample analyses; 2) component inventories are estimated using HDW model-based process knowledge and historical information; or 3) a tank-specific process estimate is made based on process flowsheets, reactor fuel data, essential material usage, and other operating data. Not surprisingly, the information derived from these different approaches is often inconsistent.

An effort is underway to provide waste inventory estimates that will serve as the standard characterization for the various waste management activities (Hodgson and LeClair 1996). As part of this effort, an evaluation of chemical information for tank 241-B-109 was performed that used:

- Analytical data from two push mode 1996 core samples (Appendix B)
- An inventory estimate generated by the HDW model (Agnew et al. 1997a)
- A comparison of the summation of individual waste types and total waste concentrations with similar 241-B Tank Farm tank samples.

Based on this evaluation, a best-basis inventory was developed for tank 241-B-109 (Tables D4-1 and D4-2). The best-basis inventory for tank 241-B-109 is presented in Tables D4-1 and D4-2. The inventory values reported in Tables D4-1 and D4-2 are subject to change. Refer to the Tank Characterization Database for the most current inventory values.

Best-basis tank inventory values are derived for 46 key radionuclides (as defined in Section 3.1 of Kupfer et al. 1997), all decayed to a common report date of January 1, 1994. Often, waste sample analyses have only reported ^{90}Sr, ^{137}Cs, $^{239/240}Pu$, and total uranium, or (total beta and total alpha) while other key radionuclides such as ^{60}Co, ^{99}Tc, ^{129}I, ^{154}Eu, ^{155}Eu, and ^{241}Am etc., have been infrequently reported. For this reason, it was necessary to derive most of the 46 key radionuclides by computer models. These models estimate radionuclide activity in batches of reactor fuel, account for the split of radionuclides to various separations plant waste streams, and track their movement with tank waste transactions. (These computer models are described in Kupfer et al. 1977, Section 6.1 and in Watrous and

Table D4-1. Best-Basis Inventory Estimate for Nonradioactive Components in Tank 241-B-109 (Effective January 31, 1997).

Analyte	Total Inventory (kg)	Basis (S, M, or E)[1]	Comment
Al	57,000	S	
Bi	<2,860	S	
Ca	<1,710	S	
Cl	750	S	
TIC as CO_3	6,870	S	
Cr	1,770	S	
F	23,900	S	
Fe	3,740	S	
Hg	59.9	M	No sample basis
K	459	M	No sample basis
La	0.05	M	No sample basis
Mn	<328	S	Near detection limit
Na	179,000	S	
Ni	174	M	Poor sample basis
NO_2	7,130	S	
NO_3	82,800	S	
OH	89,000	C	Total oxide as hydroxide
Pb	<1,630	S	
PO_4	73,200	S	ICP basis
Si	2,880	S	IC basis
S as SO_4	84,300	S	
Sr	0	M	Poor sample basis
TOC	1,080	S	
U_{TOTAL}	<13,800	S	Near detection limit
Zr	4.9	M	No sample basis

Notes:

[1]S = Sample-based (see Appendix B), M = HDW model-based, E = Engineering assessment-based, C = Calculated by charge balance

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-B-109, Decayed to January 1, 1994 (Effective January 31, 1997). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{3}H	23.6	M	
^{14}C	3.88	M	
^{59}Ni	0.265	M	
^{60}Co	5.52	M	
^{63}Ni	24.5	M	
^{79}Se	0.302	M	
^{90}Sr	8.53E+03	M	Poor sample basis
^{90}Y	8.53E+03	M	Based on ^{90}Sr
^{93}Zr	1.50	M	
^{93m}Nb	1.08	M	
^{99}Tc	33.8	M	
^{106}Ru	6.76E-04	M	
^{113m}Cd	8.41	M	
^{125}Sb	24.6	M	
^{126}Sn	0.453	M	
^{129}I	6.53E-02	M	
^{134}Cs	0.171	M	
^{137}Cs	17,000	E	Based on tank 241-B-108
^{137m}Ba	16,000	E	Based on ^{137}Cs
^{151}Sm	1.07E+03	M	
^{152}Eu	0.287	M	
^{154}Eu	67.4	M	
^{155}Eu	18.1	M	
^{226}Ra	1.83E-05	M	
^{227}Ac	8.21E-03	M	
^{228}Ra	9.01E-02	M	
^{229}Th	3.22E-03	M	
^{231}Pa	1.24E-02	M	
^{232}Th	1.09E-02	M	

Table D4-2. Best-Basis Inventory Estimate for Radioactive Components in Tank 241-B-109, Decayed to January 1, 1994 (Effective January 31, 1997). (2 sheets)

Analyte	Total Inventory (Ci)	Basis (S, M, or E)[1]	Comment
^{232}U	0.324	M	
^{233}U	1.25	M	
^{234}U	2.40	M	
^{235}U	0.104	M	
^{236}U	3.84E-02	M	
^{238}U	2.44	M	
^{237}Np	0.117	M	
^{238}Pu	3.18	M	
^{239}Pu	144	M	Poor sample basis
^{240}Pu	24.1	M	
^{241}Pu	251	M	
^{242}Pu	7.16E-04	M	
^{241}Am	4.32	M	
^{243}Am	1.41E-04	M	
^{242}Cm	9.37E-04	M	
^{243}Cm	2.25E-05	M	
^{244}Cm	9.22E-05	M	

Note:

[1]S = Sample-based, M = Hanford Defined Waste model-based, E = Engineering assessment-based.

Wootan 1997). Model generated values for radionuclides in any of the 177 tanks are reported in the Hanford Defined Waste Rev. 4 model results (Agnew et al. 1997a). The best-basis value for any one analyte may be a model result, a sample, or an engineering assessment-based result, if available. (No attempt has been made to ratio or normalize model results for all 46 radionuclides when values for measured radionuclides disagree with the model). For a discussion of typical error between model-derived values and sample-derived values, see Kupfer et al. (1997, Section 6.1.10).

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